

Effects Of Processed Dry Bird Droppings on Solar Panel Performance

IDONGESIT MONDAY OKON¹, NNOROM ACHARA², AISHA SA'AD³, ABDULAZEEZ HARUNA⁴, MARY SAMUEL⁵, MUHAMMAD MAHMUD JAMIL⁶, WILSON UWUIGBUSUN ODUWA⁷, MONDAY AMODU IMAFEDIA⁸, OWOLABI BABATOPE LAYI⁹, SHUAIBU AHMED¹⁰
^{1, 2, 3, 4, 5, 6, 7, 8, 9, 10}Department of Mechanical Engineering, Faculty of Engineering and Technology, Nigerian Defence Academy, Kaduna, Nigeria

Abstract- The performance degradation of solar photovoltaic (PV) panels due to environmental contaminants has become a significant concern in solar energy applications. This study investigated the effects of processed dry bird droppings on the performance of solar panels under outdoor environmental conditions at the Nigerian Defence Academy, Kaduna, Nigeria. Two identical photovoltaic modules were employed for the experiment: one module was maintained in a clean condition while the second module was deliberately soiled using processed dry bird droppings. Experimental measurements involving solar intensity, ambient temperature, current, and voltage were recorded at 30-minute intervals between 10:00 am and 1:00 pm over a three-day period. The results revealed that bird droppings significantly reduced the electrical output performance of the photovoltaic panel. The highest power output recorded for the clean panel was 6.330 W, whereas the soiled panel produced only 3.124 W under similar operating conditions. The highest percentage decrease in power and efficiency were observed to be 54.22% and 54.13% respectively. The findings established that bird droppings accumulation adversely affects photovoltaic efficiency and overall energy generation. The study therefore recommends regular cleaning and maintenance of photovoltaic modules in order to sustain optimum system performance.

Keywords: Solar Photovoltaic, Bird Droppings, Solar Panel Efficiency, Soiling Effect, Renewable Energy

I. INTRODUCTION

The increasing global demand for energy and the environmental concerns associated with fossil fuel consumption have intensified the adoption of renewable energy technologies. Among the various renewable energy resources, solar photovoltaic (PV) systems have gained widespread acceptance due to their simplicity, environmental friendliness, and abundance of solar radiation. Solar photovoltaic

systems directly convert sunlight into electrical energy through semiconductor materials.

Despite the growing application of photovoltaic systems, their operational efficiency is often affected by environmental factors such as temperature, humidity, dust accumulation, and bird droppings. These contaminants reduce the amount of solar radiation reaching the photovoltaic surface, thereby decreasing electrical output and overall system performance. Bird droppings are particularly harmful because they create partial shading effects and can lead to local overheating of photovoltaic cells.

The accumulation of bird droppings on photovoltaic panels has become a practical concern in many solar installations, especially in tropical regions where bird activity is common. The deposited droppings obstruct sunlight transmission and reduce the effective surface area available for solar radiation absorption. In severe cases, prolonged contamination may result in hotspot formation and permanent damage to photovoltaic cells.

This study investigates the effects of processed dry bird droppings on solar panel performance under outdoor operating conditions. The study specifically evaluates the variation of current, voltage, power output, and efficiency between clean and contaminated photovoltaic modules.

II. OBJECTIVES

The objectives of this study are to:

- i. Measure the solar intensity, temperature, current, and voltage of clean and soiled photovoltaic panels.

- ii. Determine the variation of current and voltage with time.
- iii. Evaluate the effect of processed dry bird droppings on photovoltaic power output and efficiency.
- iv. Recommend suitable maintenance practices for photovoltaic systems.

III. LITERATURE REVIEW

Several researchers have investigated the effect of environmental contaminants on photovoltaic system performance. Dust accumulation and bird droppings have been identified as major causes of performance degradation in solar energy systems.

Ali et al. investigated the impact of dust deposition on mono-crystalline and polycrystalline photovoltaic modules and reported that accumulated dust significantly reduced module efficiency and output power. Similarly, Elminir et al. observed that dust accumulation decreases glass transmittance and consequently lowers the energy output of photovoltaic systems.

Rahman et al. studied the effect of natural dust on photovoltaic panels and observed that power output reduced considerably due to surface contamination. Their findings emphasized the importance of periodic cleaning of solar panels.

Sulaiman et al. examined the influence of dirt accumulation including dust, sand, and water on photovoltaic panels under controlled laboratory conditions. The study reported that the presence of contaminants caused significant reduction in photovoltaic efficiency.

Research conducted by Nnorom Achara and Dignite Yusuf established that smaller contaminant particles have more severe effects on photovoltaic performance because they densely cover the panel surface and reduce solar irradiance reaching the cells. The reviewed literature clearly demonstrates that surface contamination remains one of the major environmental factors affecting photovoltaic system performance. However, limited studies have specifically focused on processed dry bird droppings as a contaminant. This study therefore contributes

additional experimental data on the influence of bird droppings on photovoltaic efficiency.

IV. MATERIALS AND METHODS

A. Experimental Setup

Two identical solar photovoltaic modules with similar specifications were employed for the experiment. One module served as the control panel and was cleaned regularly throughout the experimental period. The second module served as the test panel and was deliberately contaminated with processed dry bird droppings.

The experiment was conducted at the Nigerian Defence Academy permanent site, Kaduna State, Nigeria. Measurements were taken between 10:00 am and 1:00 pm at intervals of 30 minutes for three consecutive days.

The measured parameters included:

- i. Solar intensity
- ii. Ambient temperature
- iii. Output voltage
- iv. Output current

The electrical parameters obtained from both panels were used to calculate the power output, efficiency, percentage decrease in power, and percentage decrease in efficiency.

B. Experimental Apparatus

The following ranges of equipment were used during the experiment:

- i. Solar photovoltaic panels
- ii. Infrared thermometer
- iii. Digital multi-meter
- iv. Solar intensity meter
- v. Processed dry bird droppings

C. Power and Efficiency Analysis

The output power of the photovoltaic module was determined using:

$$P=IV$$

Where:

- i. P = Power output (W)
- ii. I = Current (A)
- iii. V = Voltage (V)

The photovoltaic efficiency was determined using:

$$\eta = \frac{P_{out}}{P_{in}} \times 100$$

$$P_{in} = G \times A$$

$$\eta = \frac{P_{out}}{G \times A} \times 100$$

Where:

- i. η = Efficiency (%)
- ii. P_{out} = Output power
- iii. P_{in} = Input solar power
- iv. G = Solar irradiance (W/m^2)
- v. A = Area of solar panel

V. RESULTS AND DISCUSSION

The experimental results obtained during the study indicated that bird droppings significantly reduced the electrical performance of the photovoltaic module.

A. Voltage Variation

The clean photovoltaic panel consistently produced higher voltage values compared to the soiled panel. The voltage output generally decreased with increasing panel temperature during the day.

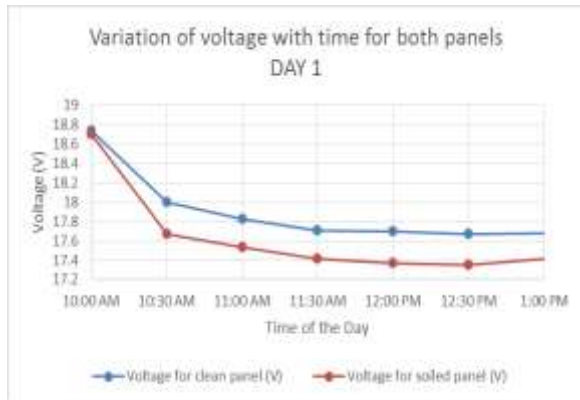


Figure 1: Variation of Voltage with Time

B. Current Variation

The output current of both panels increased with solar intensity during the day. However, the clean panel maintained higher current values compared to the contaminated panel.

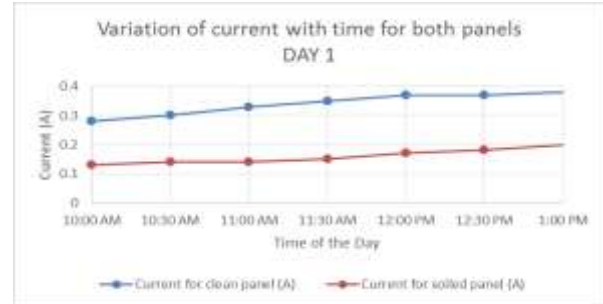


Figure 2: Variation of Current with Time

C. Power Output Analysis

The highest power output recorded for the clean photovoltaic panel was 6.330 W, while the contaminated panel produced a maximum power output of 3.124 W. This reduction clearly demonstrates the adverse effect of bird droppings on photovoltaic energy generation.

The reduction in power output occurred because the bird droppings obstructed solar radiation from reaching the photovoltaic cells effectively. The contaminant also caused partial shading which reduced current flow through the solar cells.

D. Efficiency Analysis

The highest percentage decrease in efficiency recorded during the experiment was 54.13%. This substantial reduction confirms that bird droppings significantly affect photovoltaic system efficiency.

The results obtained in this study are consistent with previous investigations which reported that surface contamination causes reduction in photovoltaic power generation and overall operational efficiency.



Figure 3: Bird Droppings on Solar Panel



Figure 4: Experimental Setup

VI. CONCLUSION

This study investigated the effects of processed dry bird droppings on the performance of solar photovoltaic panels under outdoor operating conditions. Experimental analysis showed that bird droppings significantly reduce photovoltaic voltage, current, power output, and efficiency.

The highest power output obtained from the clean panel was 6.330 W compared to 3.124 W for the contaminated panel. The highest percentage decrease in power and efficiency were 54.22% and 54.13% respectively.

The study therefore concludes that bird droppings have substantial negative effects on photovoltaic performance due to partial shading and reduction in solar radiation transmission.

RECOMMENDATIONS

- i. Solar photovoltaic panels should be cleaned regularly to minimize contamination.
- ii. Automated cleaning systems may be employed for large-scale photovoltaic installations.

Future studies should investigate the combined effects of humidity, temperature, and bird droppings on photovoltaic systems.

ACKNOWLEDGMENT

The Authors acknowledge the Nigerian Defence Academy, Postgraduate School, Faculty of Engineering and Technology, Department of Mechanical Engineering for providing the conducive atmosphere for Research and Learning.

REFERENCES

- [1] Darwish, Z. A., et al., "Effects of Temperature and Dust on Photovoltaic Performance," *Renewable Energy Journal*, vol. 45, pp. 25–35, 2019.
- [2] Ali, H., et al., "Impact of Dust Deposition on Photovoltaic Modules," *Solar Energy Research*, vol. 78, no. 4, pp. 112–120, 2017.
- [3] Elminir, H. K., et al., "Effect of Dust on Solar Photovoltaic Performance," *Renewable and Sustainable Energy Reviews*, vol. 20, pp. 120–129, 2016.
- [4] Rahman, M. M., et al., "Influence of Dust on Solar Panel Efficiency," *International Journal of Energy Research*, vol. 12, no. 3, pp. 55–63, 2018.
- [5] Sulaiman, S. A., et al., "Effects of Dirt Accumulation on Photovoltaic Panels," *Journal of Cleaner Energy*, vol. 8, no. 2, pp. 89–96, 2017.
- [6] Nnorom Achara and Dignite Yusuf, "Photovoltaic Dust Accumulation and Cell Surface Temperature," *Renewable Power Systems Journal*, vol. 10, no. 1, pp. 40–48, 2020.
- [7] Sharma, D. K. and Khan, J. S., "Effect of Dust and Dirt on Photovoltaic Performance," *Solar Technology Review*, vol. 15, no. 2, pp. 88–95, 2019.
- [8] Umar, A., et al., "Photovoltaic Performance Degradation Caused by Dust Accumulation," *Energy Conversion and Management*, vol. 50, no. 6, pp. 145–152, 2021.
- [9] Wang, T., et al., "Dust Deposition Modelling on Photovoltaic Modules," *Solar Energy Materials and Solar Cells*, vol. 125, pp. 300–308, 2020.
- [10] Spring, A. K., "Dust Accumulation on Concentrated Solar Power and Photovoltaic Surfaces," *Renewable Energy Systems*, vol. 35, no. 5, pp. 211–220, 2019.